*To be presented at the ACEEE 2002 Summer Study on Energy Efficiency in Buildings, August 18- 23, 2002. Asilomar, CA: American Council for an Energy-Efficient Economy*

# Web Technology to Support Work Processes in Energy Policy Research - A Case Study with Energy Efficiency Standards

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## ABSTRACT

This paper focuses on a process to design and build a web-based system to assist staff in day-to-day management and contemporaneous documentation of their work. Other groups that want to use web technology to support their work could apply the approach presented here, but the design itself pertains to a particular set of issues in a unique context. Each user must apply the approach to identify their objectives and design a site to meet them. The main question that the Energy Efficiency Standards Group addressed was: "How can we facilitate documentation of interim results and final products while conducting a complex, interdependent set of analyses by multiple authors under time pressures for delivering a final product?" The approach to address this question includes categorization of the components of the work, discussions with staff, development of infrastructure support for documentation, implementation of the documentation process and integration with the workflow, and follow-up with staff. The search for a solution raised a number of issues such as the need for a thorough understanding of the work, consensus building by inclusion of key staff, and deliverable scheduling to allow for contemporaneous documentation. Documentation results vary among the product analyses, from extensive internal and external use to much slower adoption. Complaints include the length of the input forms and pressure from clients to deliver results. But with repeated demand for interim output, the need for thorough contemporaneous documentation still remains. Accordingly, as problems arise there is continued commitment among the staff to address them.

## Background and Objective

The Energy Efficiency Standards Group of the Lawrence Berkeley National Laboratory (LBNL) conducts benefit-cost analysis of possible U.S. energy efficiency standards for energy-using appliances, equipment and lighting. Given the regulatory process in which they are engaged, it is often necessary for the staff to respond to questions and provide analyses on short notice for Department of Energy staff and ultimately for various stakeholders. Comprehensive documentation of the group's work is therefore needed not only at the completion of each rulemaking, but throughout the course of their analysis.

The work described in this paper and the issues addressed as it was carried out are in response to the following workflow question: How can the documentation of a complex, interdependent set of analyses by multiple authors be facilitated as the work is being

conducted when the staff is under tremendous time pressures to deliver not only a final product but also numerous interim results?

This question and the context in which it arose pointed toward the need for automation of the documentation process and its integration with the work process. In this manner, documentation could be accomplished efficiently while the work itself was being conducted. The remainder of this paper will cover the general approach taken to address the question, the application of this approach to the work of the Energy Efficiency Standards Group, and the issues that arose as a web-based tool was designed and built. Although the issues are discussed in a specific context of development of a web-based tool to facilitate work and information flows in energy standards analysis, the issues are relevant to other types of research in which web technology is contemplated to improve the work process.

Before describing the approach, it is useful to clarify what is meant by documentation. Documentation is the written description of the work to:

- explain the methods, calculations and results,
- identify the information sources and assumptions, and
- trace the use of all inputs throughout the analysis (whether collected, assumed, or derived as intermediate output).

In this context it is important to distinguish between documentation after project completion and frequent documentation during the work process. This project focuses on the latter. There are a number of advantages to documentation that is contemporaneous with the work process, and there are some disadvantages. The advantages include improvements in:

- quality control by staff of their own work,
- explanation of analysis to program managers and stakeholders,
- consensus rulemaking,
- peer review,
- resumption of analysis after delays,
- transfer of work among the staff and to new staff, and
- overall quality of the work.

There are also reductions in:

- the number of questions posed when intermediate output is accompanied by documentation,
- the number of mistakes and consequent repetition of work, and
- the time required for documentation and report preparation. The disadvantages are that it:
- diverts time and energy from data collection, model building, analysis and preparation of responses to the funding client,
- delays response time to the funding client, and
- breaks the train of thought between steps in the analysis.

The advantages and disadvantages can be viewed as the benefits and costs in a life cycle cost calculation. A research group can decide to pay the cost of delay and breaks in continuity of the analysis. In return, they realize the benefits of fewer mistakes and reduced time spent on responses to stakeholders, documentation and report preparation.

## Approach

The work to address the question stated above may be summarized as follows: identify the input and output that need to be documented; break the work down into categories because different types of work have different documentation requirements (e.g., the documentation requirements for a model are different from those for a database); examine the workflow; design a framework for a computerized tool to assist staff with documentation that includes all the elements of the group's work and reflects the order in which they conduct it; decide what kind of infrastructure or tool to use; decide whether to build it in-house or to begin with a commercially available product; design input forms that include fields for the documentation requirements; implement the design; test it; train the staff in its use; follow up to determine where there are problems; and address the problems.

These tasks were carried out in five major stages.

1. Review and categorize the major components of the group's work, such as databases, models, simulation results, workshop presentations, technical support documents and support for official government notices. Attention was given to the order in which the components were used in the work process and the interdependencies between components. This provided an overall picture of the workflow and information flow. The objective of the review was to prepare for discussions with staff and for the design and initiation of the process.
2. Conduct discussions with staff regarding documentation.
   The discussions took place with the group leader, then with the managers, and later with a broader spectrum of the staff. The purposes were to develop consensus and cooperation and to obtain staff's suggestions for documentation requirements. In practice, discussions took place repeatedly throughout the project as the design evolved and feedback from the staff was wanted.
3. Develop infrastructure support for the process.
   This included, for example, screen design, information requirements, links to the documentation database, links to original documents, etc. This step eventually evolved from two distinct web sites into the creation of a combined framework from which the staff could both manage the day-to-day activities of the projects and contemporaneously write the documentation for them. The objective was to facilitate documentation with automated support where practical.
4. Implement the documentation process and integrate it with the workflow of the projects.
   This included assignment of responsibilities for documentation and for review and quality control of documentation, and training staff in the use of the tool that was developed.
5. Follow up the documentation activities.
   The objective was to identify where these activities were successful and where they may be deficient so that remedies could be developed.

## Case Study

### 1. Review and categorize the major components of the group's work

Figure 1 shows a schematic of the workflow for the analysis of an energy efficiency standard in a rulemaking. There are many types of information and analyses that support the rulemaking. The output of one analysis often serves as the input to another (note the arrows in the "Analysis" column, and the various types of inputs connected to them). Because of this interdependence, the capability to trace the source, use and effect of any given input or result is very valuable.

The left most column indicates that there are four major stages of analysis: Framework, Advance Notice of Proposed Rulemaking, Notice of Proposed Rulemaking, and Final Rule. At each stage, the overall analysis is comprised of a series of separate but linked analyses (fourth column from the left), e.g., Market and Technology Assessment, Engineering, Lifecycle Cost, etc. These analyses are conducted by gathering data, both qualitative and quantitative (third column from the left), constructing models, running simulations, conducting workshops, summarizing and drafting possible responses to comments, etc. These components are the building blocks of the analysis.

Each component has different attributes, and therefore different documentation requirements. For example, for an information source (e.g., databases, reports, books, etc.), basic bibliographic information is appropriate (author, title, date, page number, etc.). For a model, the objective, equations, variables, output, use of the output, model modifications and model developers are key documentation items. For a simulation, documentation items include the objective, simulation parameters, and an explanation of the results. The stages, analyses and components, derived directly from a review of the workflow, and attributes of each component with its unique set of documentation requirements, form the basic organizing principles for the web site described below.

**Figure 1. Analysis to Support Energy Efficiency Standards Rulemaking**

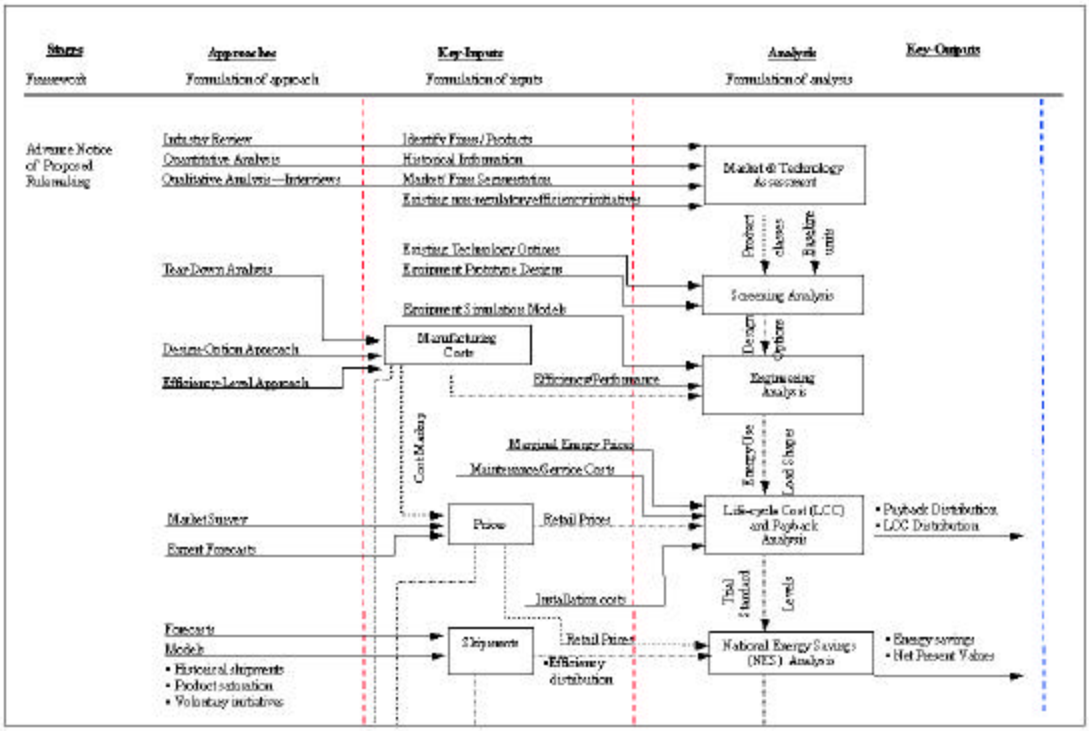
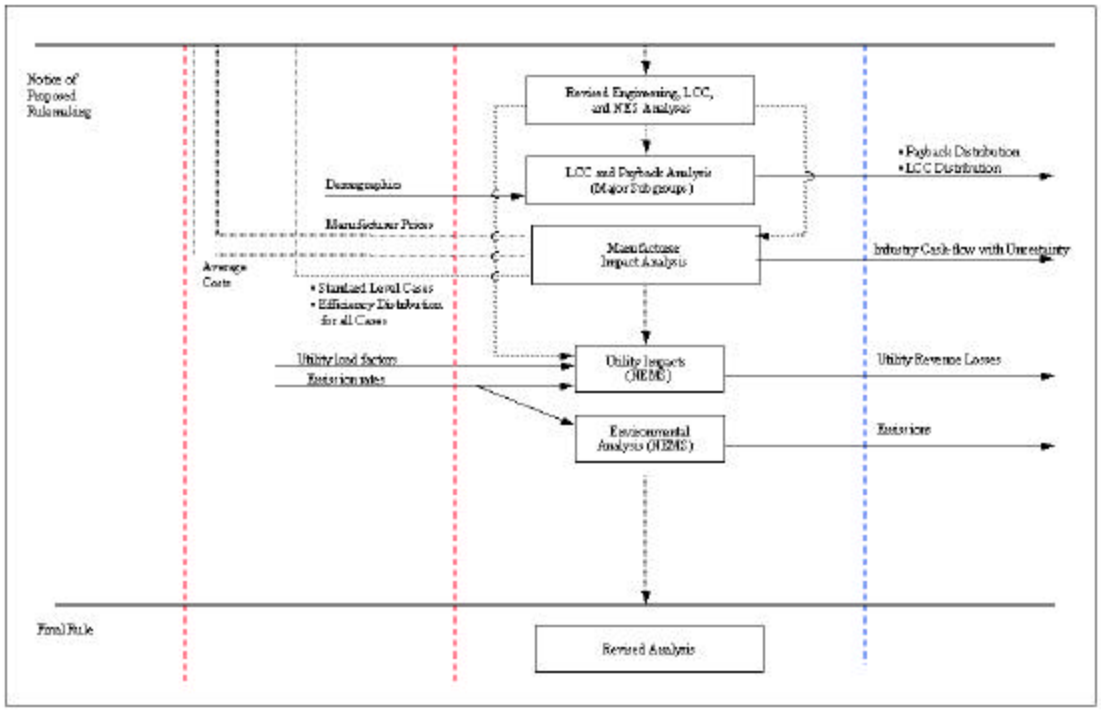


**Figure 1. (Continued) Analysis to Support Energy Efficiency Standards Rulemaking**




## 2. Conduct discussions with staff regarding documentation.

The discussions with staff were conducted first with the group leader, next with six product managers, and third with a larger group of approximately twelve staff analysts. A discussion guide was developed prior to the meetings. The topics covered included the definition of what constitutes adequate documentation, the intended focus on documentation that is contemporaneous with the work being carried out, staff's perceptions of the advantages, disadvantages and major obstacles of this approach, their proposed solutions for dealing with these obstacles, and the mechanisms that they would want in place to implement the proposed approach. Some of the subjects mentioned by staff during the discussions were:

- the time required to document work, especially as the work is being conducted;
- the need to schedule deliverables to allow for contemporaneous documentation;
- the discretion involved in what to document, and to what degree of detail;
- assignment of staff to document work across products;
- hiring of a technical writer;
- accommodation to varying work styles among the staff, and varying demands for work by clients;

- creation of a structure in which to store work and its documentation;
- creation of forms for entry of information;
- flexibility in the design of the site and the forms to allow for entry of unanticipated information;
- the need for continuous reinforcement and review of the documentation process;
- the potential benefits to the staff from a central repository of documented work.

### 3. Develop infrastructure support for the process.

The development of infrastructure support involved a series of decisions. We decided to automate the documentation and project management processes, use a web based tool, adapt a commercial software package for website construction that was not specifically designed for documentation or project management, design the site to mirror the group's workflow, and create custom input forms. The reasons for automation and selection of a web-based tool are presented below (please see "The choice of medium" in the "Issues" section).

Regarding the choice of in-house construction or purchase of a commercially available product, we opted for the latter, but only in the most general sense. That is, we selected a tool designed for rapid construction of a web site that can be configured to suit each user, with an underlying database and a search and retrieve function. Initially four people were assigned for a short time to identify and review commercial products that could be used to meet our objectives (see the definition of documentation above). We found many version-control document management systems (not what we wanted), and many project management tools that track tasks and schedules (only a fraction of the features we wanted). We did not find any products that allowed for creation of a design that fit our workflow, and that provided prompting for and storage of varying documentation requirements depending upon the entity being documented (e.g. databases, models, simulations, reports, workshops, responses to stakeholders' comments). Consequently, we adapted a very general web site construction product to suit our specific requirements in several respects. We designed for each product analysis a hierarchy of web pages to mirror the stages, specific analyses, and components of analyses as follows.

- Products e.g. individual appliances such as residential furnaces and boilers, commercial unitary air conditioners, distribution transformers
  - Stages of the rulemaking e.g. Framework, Advance Notice of Proposed Rule, etc.
    - Analyses e.g. Life cycle cost
      - Components and inputs to the analyses e.g. models, data, simulations, etc.
        - Documentation of components and inputs e.g. actual descriptions and/or references that document the analysis
        - Attachments of or links to models, data, reports, etc.

To establish a common protocol for the documentation of each component, the following forms were created to enter the information.

- Model - to document spreadsheets and other analytic tools;
- Data Collection – to record sources of data, test results and projections;
- Computer Simulation – to document simulations that support the analyses;
- Telephone/In-Person Conversation - to document information obtained in conversations;

- Project Formulation and Reports - to record summary information about reports

Each form contained named fields to prompt users to enter information specific to the component being described (see Figure 1 for examples). Moreover, each form contains four search terms, corresponding to the relevant product, stage, analysis and component that describe its position in the site. The terms are presented in pull-down menus, with default values set. Additional fields were provided for terms to be added for specific workshops and issues to which the staff responds during the analysis.

Add-ons were purchased to provide additional functionality:

- A navigation tool that presents a map of the site with an expanding tree structure,
- An email sorter that routes incoming email to selected locations automatically,
- A search function that supports searches of documents based on position in the site, and shows the positions of the items retrieved,
- A module that provides the user with alternative views of the database according to properties that can be assigned to the entries retroactively.

## 4. Implement the documentation process and integrate it with the workflow.

We created a blank template of a prototype site, then copied and modified it to each product manager's needs. For example, one rulemaking involved more than one product. A multi-product site was created to accommodate the project components that would be created and documented at different stages of the overall rulemaking for the two products. Wherever possible, default values for search terms were set on the input forms throughout the sites. Additional "locations" for project administration were established as they were requested.

We considered maintaining two sites for each project – one for day-to-day project operation, and another for contemporaneous documentation. Ultimately the consensus was to integrate both functions in one site. The challenge was to maintain uniformity of the documentation framework to facilitate information entry and retrieval and efficient movement of staff across analyses, and simultaneously provide the product managers with the flexibility to structure the site as the analyses evolved. The solution was to maintain a uniform structure to a specified level of detail for the documentation material, and to design a protocol for site expansion below that level to suit the individual product analyses. For example, if the data location of the site required expansion, it would be expanded within this location as subdivisions of it.

Once the sites were established, responsibilities for documentation, site support, and review and quality control of entries were assigned. Training sessions were provided for key members of the staff.

## 5. Follow up the documentation activities.

The sites were scanned for content. Discussions with product managers were scheduled to identify problems and solutions. The need for additional training arose. Toward that end, the steps for using the most common features of the site have been written out as user instructions.

An issue that arose in the planning phase of the site and that was raised again during these discussions is that of scheduling the deliverables to allow for contemporaneous

documentation. This function is still viewed by some as an interruption to the work, but the benefits such as the reduction of both client questions and the total time spent on describing the work are more and more evident. Nevertheless, the scheduling to allow for documentation continues to be an issue that must be resolved incrementally over time.

## Issues

The search for a solution to the workflow question stated at the beginning of this paper raised a number of issues that needed to be addressed. They are:

- Thorough understanding of all aspects of the work, including objectives, data, modeling, work and information flows, and use of output,
- Definition of the tool objectives, including functionality, intended users, and site use,
- Deliverable scheduling to allow for contemporaneous documentation,
- Consensus-building by inclusion of key staff throughout the process,
- The choice of medium, and specifically, whether to choose a web-based solution,
- The choice between in-house construction and purchase of a commercial application,
- The role of input forms to identify information requirements and facilitate retrieval,
- Security for multiple classes of users with different levels of permissions, and
- Integration of documentation and day-to-day project operation in one software application

A discussion of each issue is presented below.

**Thorough understanding of all aspects of the work, including objectives, data, modeling, work and information flows, and use of output**

A comprehensive understanding of the work is necessary for several reasons. The objectives of the work and the audience for whom it is intended influence the choice of the components which are appropriate to document and to what degree of detail. An understanding of the workflow and information flow helps to influence the design of the documentation process so that it reflects the work process. This renders it easier for the staff simultaneously to conduct and document their work. An understanding of the interconnections of the models and data, and the intermediate and final output help to identify additional documentation requirements that enable researchers to trace results back to their sources. In summary, an understanding of the workflow and objectives are necessary to design tools that assist staff in conducting their work more efficiently.

**Definition of the objectives of the computerized tool, including functionality, intended users, and application of the information facilitated by use of the tool**

Documentation and project management, terms that are used frequently in research, have a variety of definitions, and ones that are not mutually exclusive. Especially if a computerized tool is to be constructed to facilitate these activities, the objectives must be clearly defined so that the capabilities built into it perform the desired functions. For example, among the functions that could be incorporated into documentation software are: version control, task scheduling, email routing, document storage, cataloging and retrieval, descriptions of work, sources of inputs, model storage, etc. Without a clear understanding of the tool objectives, the risks are either of winding up with a tool that does not fulfill all the

functions required, or that grows into a much bigger project than is originally envisioned or wanted. The purpose of the tool, the skills and time constraints of the users, the spectrum of people who ultimately will have access to the tool, the capabilities of the software that is to be used, and the resources to construct the tool all must be accounted for in determining the functions that are ultimately incorporated.

**Deliverable scheduling to allow for contemporaneous documentation**

Documentation requires time. If the deadlines are not scheduled to account for this activity, documentation is unlikely to be completed until the end of the analysis. For this reason, although the deliverable schedule is not a component of the technical infrastructure for documentation, it is nevertheless integral to its success if it is to be written as the project evolves.

**Consensus-building by inclusion of key staff throughout the process**

The purpose of including the staff in the development process is to introduce to them the ideas for the documentation process, obtain their feedback about the proposed process, obtain agreement on what is feasible, and build consensus for timely, comprehensive documentation. The staff performs the work and is therefore in the best position to document it. Their cooperation is essential to the success of the documentation process. Consequently, the formulation of the solution to a workflow question must not only include their input, but must be one that they will support. This applies not only to the initial formulation of the design, but to modifications that are made as the work evolves. Accordingly, it is valuable to involve staff throughout design and implementation as new decisions are about to be made.

**The choice of medium, and specifically, whether to choose a web-based solution**

The first node in the decision process of medium choice is whether to automate a particular function, in this case, the documentation of the group's work. The decision was made to automate because of the time pressures under which the staff works. These time pressures result in documentation usually being postponed until the end of the analysis. The question then is what type of automation is appropriate. Forms in conjunction with written guidelines standardized documentation subdirectories within the existing file structure, commercial documentation software (if available), and web-based technology all were considered. For the same reasons that automation was preferred, a comprehensive computerized tool was considered the best solution to facilitate documentation in a work process characterized by severe time constraints. The time constraints also augured for a solution that would present as little interruption to the work process as possible; therefore a tool that was structured like the work process itself was considered desirable. Web technology was an obvious choice because a website could be designed to reflect the work process. For example, a hierarchical structure of web pages could be used to represent the various stages in the analysis process, and nested pages within them could represent the various types of analyses that are required at each stage. Moreover, a web-based tool would afford easy access to project material. Staff could share information both onsite and offsite, and diverse elements such as databases, models and other materials easily could be brought in to a central project repository. Stated alternatively, the point and click attributes of web

technology are attractive for the automation of some work processes with the following characteristics:

- The work is conducted collaboratively;
- The work processes and information flows are complex and interdependent (e.g., some of the output must be readily available in preliminary form to be used as inputs to other analyses);
- Flexibility in the organization of the tool is desired in order to reflect the complexity of the work process;
- The inputs are diverse and are sometimes shared; and
- Search and retrieval of documentation entries are important functions.

**The choice between in-house construction and purchase of a commercial application**

The choice is whether to write the entire code for the user interface, the underlying database and all of the site's functions, or to select and adapt commercially available software. The choice involves a tradeoff. The purchase of commercial software enables the user to take advantage of an established database, search engine, existing software to create input forms, an established security system, and other features already in place (e.g. calendar, task list, online tutorial, etc.). It also saves the user the staff time and/or the money that would be incurred to develop these features. However, by purchasing commercial software, the user gives up access to portions of the underlying code, the flexibility of determining how the database is structured, the appearance and features of the input forms, the robustness of the search engine and site map, and the overall look and feel of the computerized tool (e.g., color, font, layout). Even the decision to consider purchase of commercial software involves a time commitment to evaluate the array of commercially available products to determine if there are any that are suitable and at what cost. The choice is also influenced by the expertise available in-house, and time commitments to other work.

**The role of input forms to identify site information requirements and to facilitate their retrieval**

One of the major objectives of the tool is to facilitate documentation of the work as it is in process. Included in this objective are an identification of the elements that need to be documented and the specific documentation requirements of each element. As mentioned above, the requirements vary by element. A bibliographic reference (e.g., author, title, institution, date, page number, etc.) is sufficient to identify a published data source used in the analysis, whereas a much lengthier description is required for a model that is developed. For example, the requirements may include the objective of the model, modules or components that comprise the model, use of the results, selection of assumptions and their rationale, definition of variables, statement and explanation of formulas (including relationship of the independent variables to each other and to the dependent variable), selection of probability distributions and their rationale, links and interdependencies with other models and databases, version number, date of the version, and model developer(s). Moreover, as changes are made to the model, additional documentation is needed. This includes a description of the changes made, the objective of the change, its result, date, the name of staff making the model development or change, and a contact for technical questions.

An input form is a convenient way to identify these documentation requirements for the user. They can be presented on the form in an organized format for subsequent use in reports, and use of the form facilitates their entry and retrieval by the staff. Input forms incorporated in a computerized tool can be used to attach default and elective search terms to each entry, to supply dropdown lists for selected fields where the array of choices can be predicted, to reference files or attach them to the computerized tool, and to provide guidance for the topics to include in the narrative descriptions of the work. The fields on the form represent the set of prompts from which the user begins to enter information, but for the designers of the tool, they are the culmination of the analysis of the inputs and outputs from which the documentation requirements are derived.

**Security for multiple classes of users with different levels of permission**

Access to information is related to the objective of the site, particularly whom the site should serve, and what functions it should provide to each type of user. Among the questions to be addressed are:

- Is the information in the site intended for internal use only, and if not, is it to be accessible to funding organizations, interested stakeholders, and/or the public at large?
- For each category of possible user, what type of access is to be granted, e.g., read only, read/write, all of the above plus edit, all of the above plus delete, all of the above plus augment or alter the site structure?
- What portion of the information in the site is to be made accessible to each category of user?
- Can portions of the site easily be duplicated and made accessible to outside users while other parts of the site are isolated for internal use only?

These questions must be resolved with respect to the overall objectives of the group. They also bear upon the choice of platform and software that is selected to address work process issues. The greater the number of groups that require access to the information, and the more varied the type of access that must be built into the system, the more robust the security function of the software must be.

**Integration of documentation and day-to-day operation of the project in one software application**

The more integrated the computerized documentation tool with the work itself, the more convenient it is for staff to document their work as they conduct it. Conversely, the more that staff need to transfer work from one application to another, the more an impediment exists to the smooth flow of work and the completion of the documentation process.

Integration of the functions involves a tradeoff. The staffs gain the convenience of centralizing the project elements in one application. The costs they incur are the difficulty and compromises that may ensue in order to incorporate all the requisite functionality. For example, among the attributes required for project documentation are: detailed input forms to prompt users for the requisite information, uniform structure and organization of material across projects to facilitate storage and retrieval, search capability, and security. Among the attributes desirable for the day-to-day operation of the project are a flexible structure to accommodate the work as it evolves, a calendar and project schedule, task lists, email

sorting, search engine, and security. While there is some overlap, there are also some differences. These differences become especially important if one wants to purchase a commercially available application. Rarely are all the functions found in one application.

The decision of whether or not to integrate the functions ultimately depends upon the weights given to the various advantages and disadvantages, and the assessment made by the management and staff as to the route that will most enhance the probability for carrying out all of the functions successfully.

There are no guarantees to success in the change and automation of a workflow process in general, and a web-based one in particular. Nevertheless, attention to these issues will increase the likelihood of their successful implementation. The issues are presented in a linear fashion in this paper. However, the process to design a change is non-linear; many issues must be considered simultaneously. The researcher must assess the conditions of the situation in question and address the issues accordingly. Mid-course adjustments and provisions for feedback are necessary for success.

## Conclusions

The experience with the web-based tools varies among the product managers. In one analysis the tool is used daily for many phases of the project – documentation, communication, document sharing, document storage. A site for client use has been constructed and has been well received. They find it convenient to have access to the latest version of a spreadsheet model on the site and to be able to discuss it by telephone with LBNL staff as they are simultaneously viewing the same model.

For other product analyses adoption has been slower. Complaints about the tool include the time required to learn its use, computer processing time for some operations, the length of the input forms, the pressure from the clients to deliver results from additional simulations, and interruptions to the continuity of the work from having to document contemporaneously.

It is too early in the process to determine how much of an impediment each of these objections is to the widespread use of the tool. But with repeated demand for interim output, the need for thorough contemporaneous documentation still remains. Notwithstanding the transition issues, the product managers are in accord with the group leader in this regard. Accordingly, as problems arise there is continued commitment to address them e.g. with purchase of additional servers, evaluation of higher speed intranet connections, negotiations for deadlines that account for contemporaneous documentation, additional training sessions for staff, etc. The tool has not been in existence long enough for the staff to experience a complete cycle of their work with it. Consequently we do not yet have an estimate of improvement in timesavings or other dimensions of efficiency. But we know that it is valuable to include staff early in the design process, and to consult them often as the tool is being developed and after it is in use.

Another group within the Laboratory has evaluated the Energy Efficiency Standards Group's use of web technology and is considering adapting it to their needs. It would be appropriate to apply the approach described above, but the tool as it is designed now probably would not be suitable. It was designed to address a particular set of issues in the context of a unique workflow. Each user must identify their objectives and design the site to

meet them.

## Acknowledgment

This work was supported by the Assistant Secretary for Energy Efficiency and Renewable Energy, Office of Building Technologies of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.